

ASSESSMENT OF KARST FEATURES UNDERLYING LAKE SEMINOLE, SOUTHWESTERN GEORGIA AND NORTHWESTERN FLORIDA, USING ORTHORECTIFIED PHOTOGRAPHS OF PREIMPOUNDMENT CONDITIONS AND HYDROGRAPHIC MAPS

Lynn J. Torak

AUTHOR: Hydrologist, U.S. Geological Survey, 3039 Amwiler Road, Suite 130, Peachtree Business Center, Atlanta, Georgia 30360-2824.

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Abstract. Surface expression of karst-dissolution features in limestone units of the Upper Floridan aquifer underlying Lake Seminole, southwestern Georgia and northwestern Florida, is evident in preimpoundment aerial photographs and recent hydrographic maps of the lake bottom. Orthorectification of preimpoundment aerial photographs with U.S. Geological Survey Digital Raster Graphics files corresponding to 1:24,000-scale topographic maps allowed construction of a map of karst features in the impoundment area. This map provides a necessary tool to assess the likelihood of increased limestone dissolution and to evaluate the potential for sinkhole collapse and high rates of vertical leakage (lake outflow) beneath the lake. Comparison of aerial photographs with recent hydrographic maps prepared by the U.S. Army Corps of Engineers and with maps showing navigation channels and locations of in-lake springs indicates that the orthorectified photographs contain details of karst features that can be used to enhance knowledge of lake-bottom hydrography and further understanding of lake-aquifer interaction.

INTRODUCTION

Lake Seminole is a 37,600-acre lake located along the Georgia-Florida State line in extreme southwestern Georgia and northwestern Florida (Fig. 1). The lake was filled to its normal-pool elevation of 77 feet in 1957 following construction, by the U.S. Army Corps of Engineers (Corps), of Jim Woodruff Lock and Dam on the Apalachicola River, about 1,000 feet downstream of the confluence of the Flint and Chattahoochee Rivers (U.S. Army Corps of Engineers, 1981). Primarily built to aid navigation and generate hydroelectric power for neighboring communities, Lake Seminole is the headwater of the Apalachicola River and provides about 33 feet of lift to vessels traveling upstream through the lock and dam into the lake (U.S. Army Corps of Engineers, 1981).

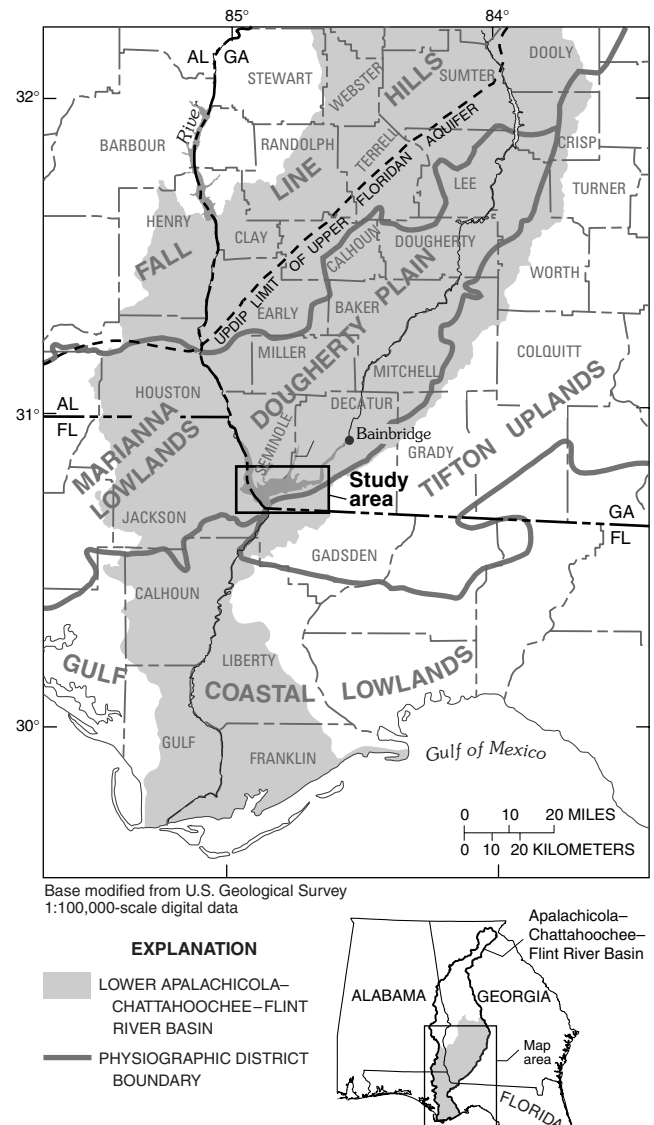


Figure 1. Location of study area, boundaries of the lower Apalachicola–Chattahoochee–Flint River Basin, and physiographic districts of the Coastal Plain Province (modified from Torak and others, 1996).

Lake Seminole is emplaced in limestone of the Upper Floridan aquifer in the Dougherty Plain and Marianna Lowlands divisions of the Coastal Plain physiographic province (Puri and Vernon, 1964). The Upper Floridan aquifer receives recharge along the northwestern boundary of the Dougherty Plain, where the several-hundred-foot-thick sequence of friable and easily weathered limestone of Eocene and Oligocene age is located at or near land surface. The late Eocene Ocala Limestone extends throughout the 6,800-square-mile area of the lower Apalachicola-Chattahoochee-Flint River Basin from the outcrop area along the northwestern boundary of the Dougherty Plain (Fig. 1) southeastward beneath the dam. The Oligocene Suwannee Limestone crops out beneath the lake in a southwest-to-northeast-trending direction, beginning near the dam and extending about 9 miles up the Chattahoochee River impoundment arm and about 16 miles up the Flint River impoundment arm (Sever, 1965, plate 2). The lock and dam was constructed on the early Miocene Tampa Limestone, a crystalline limestone containing fuller's earth clay, which forms valley walls, creating about 160 feet of local relief adjacent to the Apalachicola River at the lock and dam (U.S. Army Corps of Engineers, 1948).

The preimpoundment landscape of Lake Seminole was characterized by an irregular and undulating topography, containing an abundance of sinks and depressions (Sever, 1965), and by heterogeneous stream-channel development in the limestone aquifer. Deeply incised remnants of former river channels contained water at levels that fluctuated independently of the river; shallow, small depressions, aligned in a general upstream-to-downstream direction in what is now lakebed, drained rapidly into the subsurface, indicating possible dissolution along a joint or fault system in the underlying limestone (U.S. Army Corps of Engineers, 1948). Numerous springs discharged to channels, or runs, that eventually flowed to the Chattahoochee and Flint Rivers and to Spring Creek (Fig. 1), characterizing a well-connected stream-aquifer system. Drilling by the Corps prior to construction of Jim Woodruff Lock and Dam penetrated cavernous and deeply weathered bedrock; most of the caverns were filled with sediment, although water-bearing open caverns were penetrated in some of the borings (U.S. Army Corps of Engineers, 1948).

In July 1999, the U.S. Geological Survey (USGS), in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division (Ga-EPD), undertook a study to evaluate the water resources of Lake Seminole and the surrounding area. A goal of the study was to investigate the hydrologic and hydrogeologic implications of the impoundment and the ef-

fect on other components of the stream-reservoir-aquifer-flow system. Part of this goal was to assess the karst limestone of the lake bottom for possible indications of lake leakage into the Upper Floridan aquifer, for the likelihood of sinkhole collapse in the lake bottom, and for the potential of sudden, partial, or complete draining of the lake (Harold F. Reheis, Director, GaEPD written commun., 1997). This paper describes an assessment of karst features in the preimpoundment lake area that was performed by evaluating aerial photographs taken by the Corps during construction of the lake, and by comparing the photographic evidence of karst features with hydrographic maps and maps showing bathymetry and navigation features. Two examples of the assessment are presented herein, focusing on part of the Flint River impoundment arm of Lake Seminole, downstream of Bainbridge, Georgia (Fig. 2), and on the area surrounding Jim Woodruff Lock and Dam (Fig. 3).

METHODS

Karst features in the bottom of Lake Seminole were assessed using preimpoundment aerial photographs and recent hydrographic maps prepared by the Corps (James H. Sanders, Jr., Geologist, U.S. Army Corps of Engineers, Mobile District, Mobile, Alabama, written commun., 2002), and using a map showing bathymetry and navigation features (Atlantic Mapping, Inc., 1998). Aerial photographs of the lake area were taken by the Corps in 1952 and early 1954; filling of the lake began in May 1954. The photographs were digitized and orthorectified to USGS Digital Raster Graphics representations of 1:24,000-scale topographic maps (Fig. 2A), to register the preimpoundment landscape to current topographic maps and to compare with a map showing navigation features (Fig. 2B). Details of the orthorectification process are discussed by Walls and Hamrick (2003) in a companion abstract (poster presentation) to this paper.

Hydrographic maps were compared with the orthorectified aerial photographs and map showing navigation features (Fig. 3A–D). The hydrographic maps depicted lake-bottom features in the area directly upstream of Jim Woodruff Lock and Dam and along the western shore.

Orthorectified photographs of the lake area prior to impoundment show details of karst features in the now-impounded lake bottom that are not evident on topographic maps or maps showing navigation features. The irregular morphology of springs and spring runs, which once discharged to the Flint River and now discharge to the lake bottom, is clearly visible in the aerial photo-

graphs (Fig. 2A). These springs are identified with point symbols on maps showing general navigation features and bathymetry (Fig. 2B), and springs in the lake area (Sever, 1965, plate 1). The aerial photographs indicate ponding and channelized springflow in a run that discharged to the then-Flint River (Fig. 2A). Identification of springs in the aerial photographs was aided by evaluating the extent of tree clearing performed in the unimpounded area, as there was a conspicuous lack of tree clearing near springs and spring runs.

Aerial photographs and hydrographic maps in the area of the lock and dam show steep lake bathymetry along the western lakeshore and an irregular lake bottom resembling former channels of the Chattahoochee and Flint Rivers directly upstream of the dam (Fig. 3A, B). Subsurface structures resembling sinkholes that function as reverse springs, leaking water from the lake into the underlying limestone, were identified on hydrographic maps and were identified during inspection of the western lakeshore (Fig. 3B, C). Other structures

resembling sinkholes or former stream-channel incisions were identified just upstream of the powerhouse (Fig. 3C). At one sinkhole location near the western lakeshore (Fig. 3B), water leaking to the underlying limestone created a small vortex in the lake surface. Although the vortex was a surface expression of lake leakage, the amount of leakage seemed to be minor. The vortex itself has been reported to form only during “ideal” conditions when the lake level is low, creating shallow water above the area of leakage (James H. Sanders, Jr., Geologist, U.S. Army Corps of Engineers, Mobile District, Mobile, Alabama, written commun., 2002). Bathymetric expressions of these features are not identified with the general-depth contours of the map showing navigation channels (Fig. 3D). Aerial photographs of the preimpounded lake area (Fig. 3A) were used to identify the location of several springs along the western lakeshore that were described by the Corps during construction of the lock and dam (U.S. Army Corps of Engineers, 1948, Appendix II, Chart 1.1).

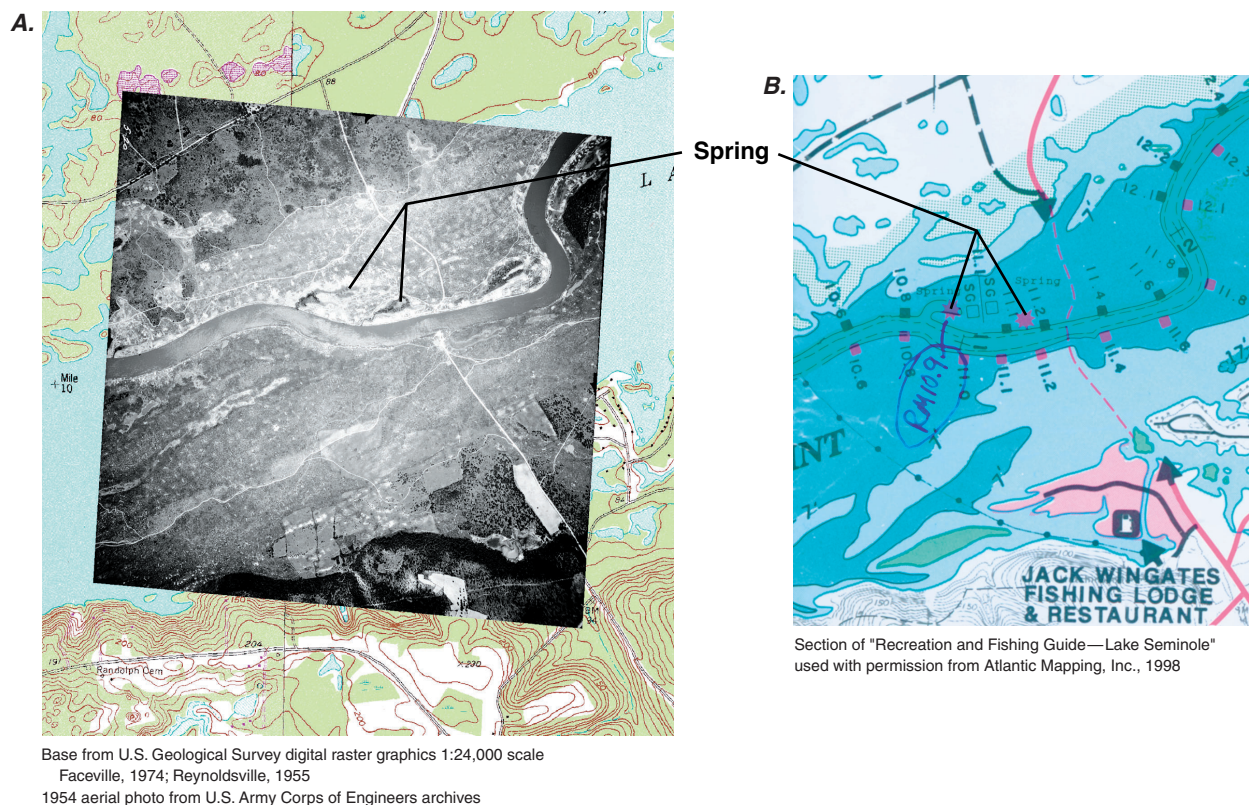


Figure 2. (A) Orthorectified aerial photograph and Digital Raster Graphics image of 1:24,000-scale topographic map of Lake Seminole area, preimpoundment conditions along Flint River downstream of Bainbridge, Georgia, showing river channel and springs; and (B) map showing bathymetric features of Flint River impoundment arm to Lake Seminole, downstream of Bainbridge, Georgia.

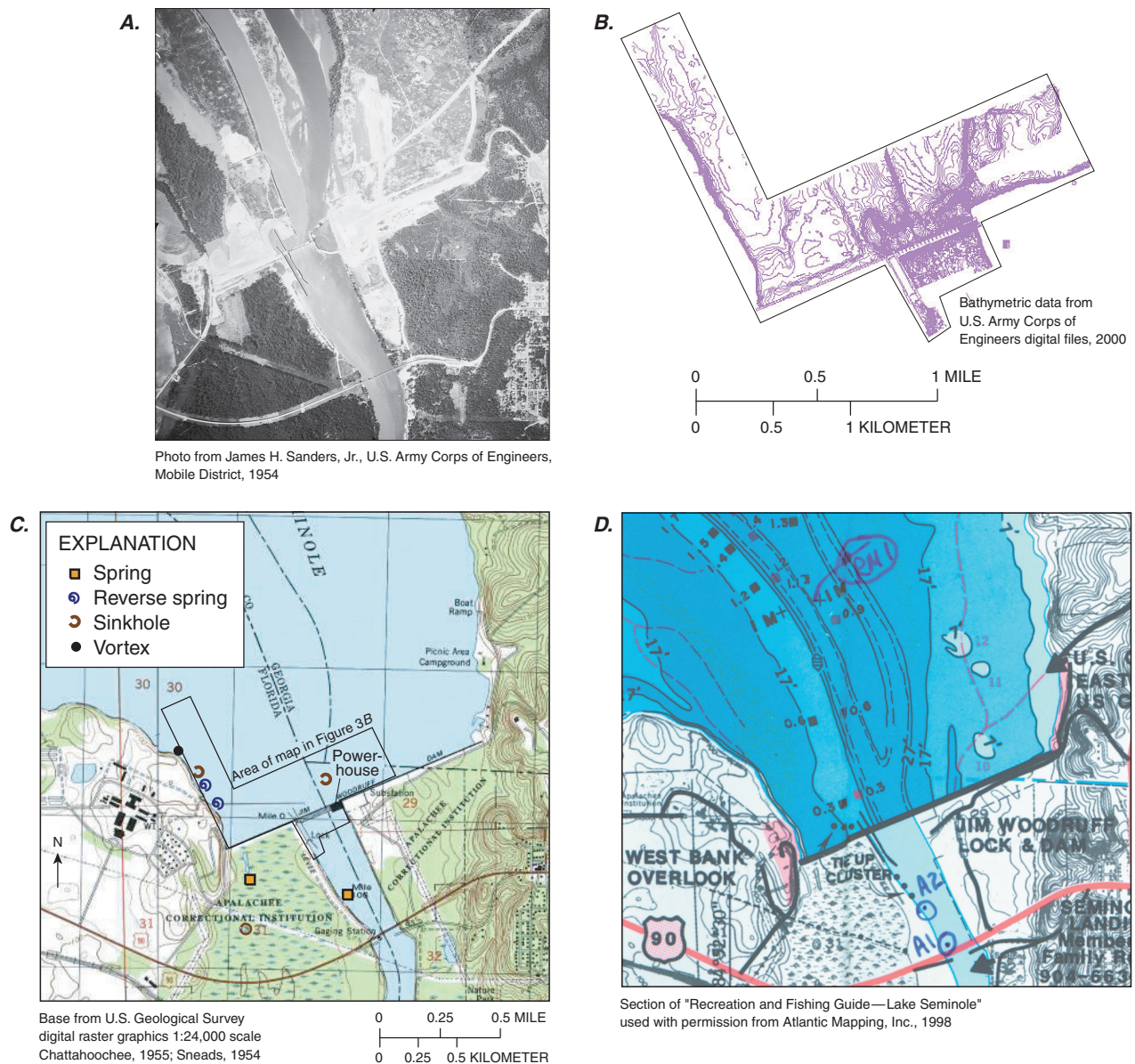


Figure 3. (A) Aerial photograph of construction site of Jim Woodruff Lock and Dam, 1954; (B) bathymetric map of impounded area directly behind Jim Woodruff Lock and Dam and along western shore of Lake Seminole (area shown in Figure 3C); (C) Digital Raster Graphics image of 1:24,000-scale topographic map of Lake Seminole showing area encompassing Jim Woodruff Lock and Dam and location of vortex, sinkholes, and reverse springs adjacent to dam; and (D) map showing navigation and bathymetric features of Lake Seminole near Jim Woodruff Lock and Dam.

SUMMARY AND CONCLUSIONS

Aerial photographs of the preimpoundment area of Lake Seminole show a more extensive hydraulic connection between the Upper Floridan aquifer and Flint River by springs, spring runs, and ponds than is shown on available maps (Fig. 2). Preimpoundment aerial photographs of the construction area for Jim Woodruff Lock and Dam show visual details of stream-aquifer

hydraulic connection that are absent from maps showing topography, navigation features, and bathymetry (Fig. 3), and support previously published accounts by Sever (1965) and the Corps (U.S. Army Corps of Engineers, 1948) of the solutioned karst landscape. Identification of karst features in preimpoundment aerial photographs corroborates their appearance on hydrographic maps and gives strong evidence for an active stream-aquifer hydraulic connection in the Lake

Seminole area prior to impoundment in 1957. However, assessing the likelihood of increased limestone dissolution and the potential for sinkhole collapse and high rates of vertical leakage (lake outflow) requires additional evaluation of flow conditions and hydrochemical analysis of water in the stream-lake aquifer system.

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